Studies on Frozen Storage Characteristics of Individually Quick Frozen and Block Frozen Mackerel

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Studies on mackerel *(Rastrelliger kanagurta)* of medium (4%) and high (11%) lipid contents quick frozen individually (IQF) and as blocks (BF) and stored at —23°C showed that block frozen mackerel had higher frozen storage shelf-life than individually quick frozen samples. IQF samples of medium and high lipid contents had shelf-lives of 17 and 20 weeks whereas BF samples of both series had 23 and 24 weeks respectively based on sensory evaluation.

Among the various species of marine food fishes, mackerel constitutes 10% of the total landings in India. This fatty fish is normally consumed in fresh condition. However during seasonal glut a substantial quantity is processed as salt cured fish. The high oil content in the fish stands in the way of preservation by freezing because of the development of rancidity during subsequent frozen storage.

Freezing characteristics of fishes like oil sardine *(Sardinella longiceps)* (Shenoy & Pillai, 1971; Chinnamma George *et al.,* 1985), spotted seer *(Scomberomorus guttatus)* (Shenoy, 1976), pomfret *(Pampus argentius)* (Kamasastri & Rao, 1967) are already reported. Lipid breakdown during frozen storage of oil sardine and mackerel was also studied (Viswanathan Nair *et al.,* 1976; 1978). This paper reports the results of the studies on the freezing and subsequent frozen storage characteristics of block frozen and individually quick frozen mackerel.

Materials and Methods

Fresh mackerel *(Rastrelliger kanagurta)* procured from mechanised fishing crafts operating off Cochin, was washed in potable water and divided into two lots. One lot was individually quick frozen at —40°C, glazed by dipping in chilled water and wrapped in 100 gauge polythene film and stored in a master carton at —23°C. Other lot was frozen as 2 kg blocks in aluminium trays lined inside with polythene film with sufficient chilled water to form a glaze over the surface of the material and frozen at —40°C. The frozen blocks were then transferred to duplex cartons and stored at —23°C.

Muscle with skin from 5–6 mackerels was taken and minced uniformly and this minced muscle was taken for chemical analysis. For bacteriological tests sample was taken in sterile dishes using sterile scissors. For organoleptic evaluation, the fishes were cleaned, cut to pieces and cooked in 2% brine for 15 min and the quality was judged by a trained taste panel.

The frozen stored material was drawn at intervals, thawed in running water and analysed as the fresh material.

Moisture, lipids and non-protein nitrogen were determined according to the methods of AOAC (1975). Peroxide value (PV) was estimated by the method of Lea (1952) and free fatty acids by the method of AOCS (1946). Thiobarbituric acid (TBA) value was determined as described by Tarladgis *et al.* (1960).

The samples were analysed for total bacterial count, total coliforms, coagulase positive staphylococci and faecal streptococci. The procedure adopted was the same as that outlined in Indian Standards (IS: 2237, 1971), except that for determination of total plate count incubation temperature of 29±2°C (room temperature) was used instead of 37°C.

Results and Discussion

The changes in moisture of mackerel for both batches, (I) 4% lipid and (II) 11% lipid, stored at —23°C are presented in Table 1. The variation in moisture content observed between two batches can be accounted for the difference in lipid content. Significant changes in moisture were not observed during frozen storage probably due to the effective protection of glaze and packing.

Table 1. *Changes in moisture (%) of individually quick frozen (IQF) and block frozen (BF) mackerel with fat content 4% (I) and 11% (II)*

Frozen storage weeks	Batch I IQF	Batch I BF	Frozen storage weeks	Batch II IQF	Batch II BF
0	72.0	72.9	0	66.3	66.3
4	72.5	72.0	5	67.0	66.9
8	73.0	72.2	10	66.0	66.7
12	72.0	72.2	15	66.5	66.8
17	72.5	72.0	20	66.5	68.3
23	72.4	72.5	24	66.0	67.1
32	72.9	72.5	—	—	—

Table 2 represents the changes in non-protein nitrogen. A definite pattern or trend is not seen in non-protein nitrogen during frozen storage.

The total plate count of the fish (Table 3) was of the order of 10^3 per g. For IQF and BF samples of both batches, the total plate count did not show any significant change. Pathogenic organisms like coliforms, streptococci or staphylococci were absent in frozen samples. The results showed that microbial changes were not significant in all the samples.

Organoleptic changes during frozen storage are presented in Table 4. For both batches block frozen samples showed better acceptability and textural properties than IQF samples. The BF samples of both series had shelf-lives of 23 and 24 weeks

Table 2. *Changes in non-protein nitrogen of IQF and BF mackerel having fat contents 4% (I) and 11% (II)*

Non-protein nitrogen mg/100g					
Frozen storage weeks	Batch I IQF	Batch I BF	Frozen storage weeks	Batch II IQF	Batch II BF
0	694	694	0	657	657
4	761	697	5	628	630
8	762	764	10	669	684
12	791	774	15	655	640
17	613	586	20	722	583
23	595	699	24	699	587
32	626	657	—	—	—

whereas the IQF samples had only 17 and 20 weeks respectively

Figs. 1a and Ib show the changes in peroxide values for IQF and BF mackerel of batch I and II respectively during frozen storage. Both IQF and BF samples showed almost similar trend. But IQF samples invariably recorded higher values compared to BF samples. For batch I, the IQF and BF samples showed maximum increase

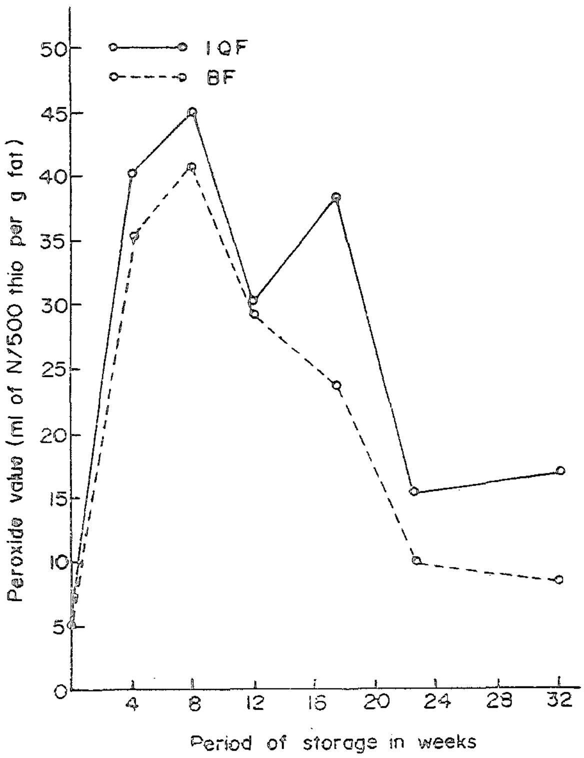

Fig. 1a. Changes in PV of IQF and BF mackerel (Batch I) during frozen storage

Table 3. **Microbiological characteristics of IQF and BF mackerel kept at -23°C*

Batch I			Batch II		
T. P. C. before freezing 1.143×10^4/g			T. P. C. before freezing 8.29×10^4/g		
Period of storage weeks	Total plate count/g muscle IQF	BF	Period of storage weeks	Total plate count/g muscle IQF	BF
0	2.293×10^3	8.135×10^3	0	1.37×10^4	5.25×10^4
4	9.767×10^3	1.89×10^4	4	4.50×10^4	4.10×10^4
8	1.89×10^4	3.20×10^4	10	1.82×10^4	1.66×10^4
12	5.05×10^3	9.70×10^3	15	1.01×10^4	1.07×10^4
17	3.05×10^3	9.194×10^3	20	3.84×10^4	6.56×10^3
23	3.08×10^3	3.31×10^3	24	7.51×10^3	1.15×10^4
32	2.06×10^3	3.87×10^3			

*Coliforms, streptococci and staphylococci were absent in all the frozen samples of both the batches. However, the raw material of batch I recorded coliforms 10 and staphylococci 70 and that of batch II streptococci 130.

Table 4. *Changes in organoleptic characteristics of IQF and BF mackerel stored at -23°C*

Batch I			Batch II		
Period of storage weeks	IQF	BF	Period of storage weeks	IQF	BF
0	Excellent	Excellent	0	Excellent	Excellent
4	Good	Good	5	Good, slightly tough	Good
8	Good to fair, slight tough texture	Good	10	Good, no rancidity	Good, no rancidity
12	Moderately tough texture, slight rancidity	Good to fair, slight rancidity and toughness	15	Fair to good	Good
17	Fair, tough, rancid	Fair, slightly tough, rancid	20	Fair, moderately tough, rancid	Good
23	Inedible, off odour, rancid, tough	Fair, tough rancid	24	Inedible, high rancidity and toughness	Fair, mild rancidity and toughness
32	Poor, highly rancid, very tough	Fair, rancid, tough			

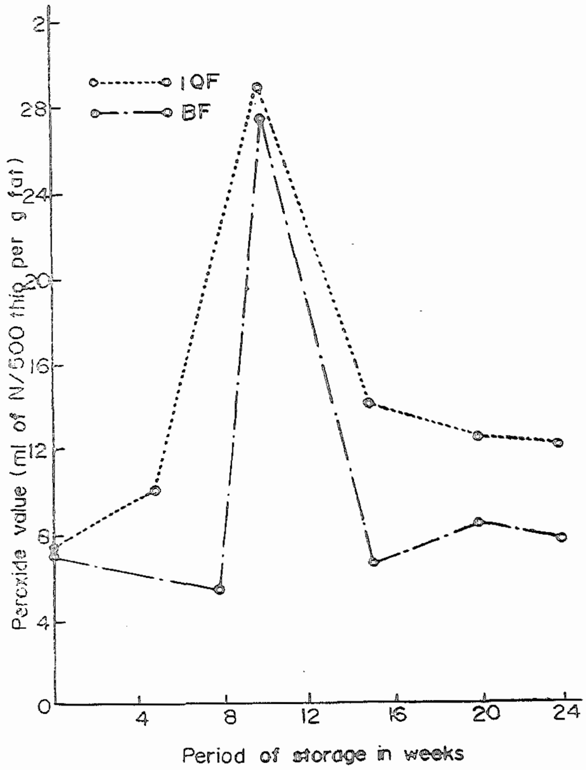

Fig. 1b. Changes in PV of IQF and BF mackerel (Batch II) during frozen storage

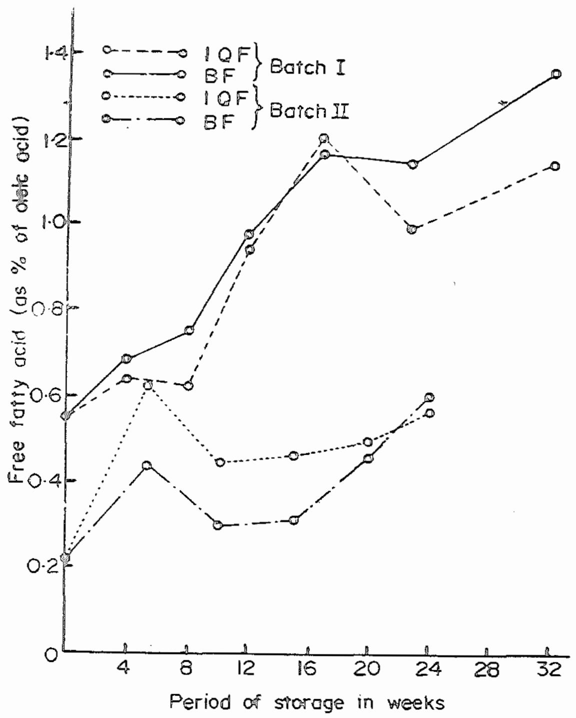

Fig. 2. Changes in FFA of IQF and BF mackerel (Batch I & II) during frozen storage

upto 8 weeks storage and thereafter recorded a declining trend.

The changes in TBA value showed a different pattern from that of PV as seen in Fig. 3a & 3b. TBA values of IQF samples showed rapid increase after 12 weeks-of frozen storage in both samples. Organoleptic evaluation has shown that there is no rancid flavour upto 8 weeks of storage. Low TBA values confirm this observation. But as storage life extends oxidation products are formed resulting in the production of 2 thiobarbituric acid reactive carbonyls.

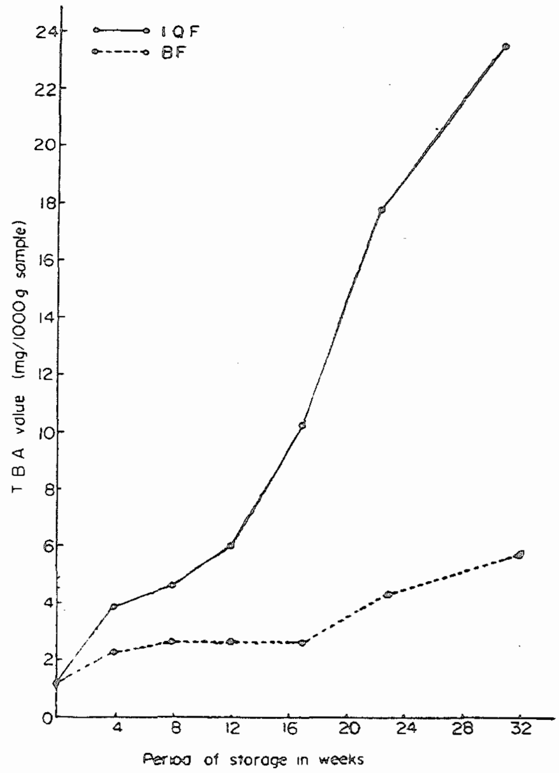

Fig. 3a. Changes in TBA value of IQF and BF mackerel (Batch I) during frozen storage

Olley and co-workers (Olley & Lovern, 1960; Olley *et al.*, 1962) noted that most of the free fatty acids in many species of fish originated from phospholipids. Viswanathan Nair *et al.* (1979) reported that in oil sardine *(Sardinella longiceps)* production of FFA is higher in muscle (lipid content 6%, compared to skin lipids (27%) during frozen storage at -18° C. The present study indicates in mackerel the lipid hydrolysis is more when the fat content is less (Fig. 2). It can be concluded that production of FFA is higher in mackerel when it is lean and lower when the fish has maximum lipid.

Fatty fishes were found to be less susceptible to protein denaturation as a result of the protective effect of lipids during frozen storage (Dyer, 1951; 1953). When lipids were hydrolysed leading to the production of FFA, proteins were denatured at faster rate (Dyer & Fraer, 1959; Dyer & Dingle, 1961). There are two possibilities (i) the FFA formed get absorbed on the surface of proteins giving a hydrophobic surface (2) the lipid hydrolysis results in loss of protective effect of lipids on proteins. Consequently fatty fishes can have an extended shelf-life in frozen storage compared to lean fish. This is found to be applicable to mackerel, which can be both lean and fatty at different seasons. However, this is not the case always and different species behave differently because of the difference in the type of FFA released and its inherent capacity to make myofibrillar protein insoluble (King *et al.,* 1962).

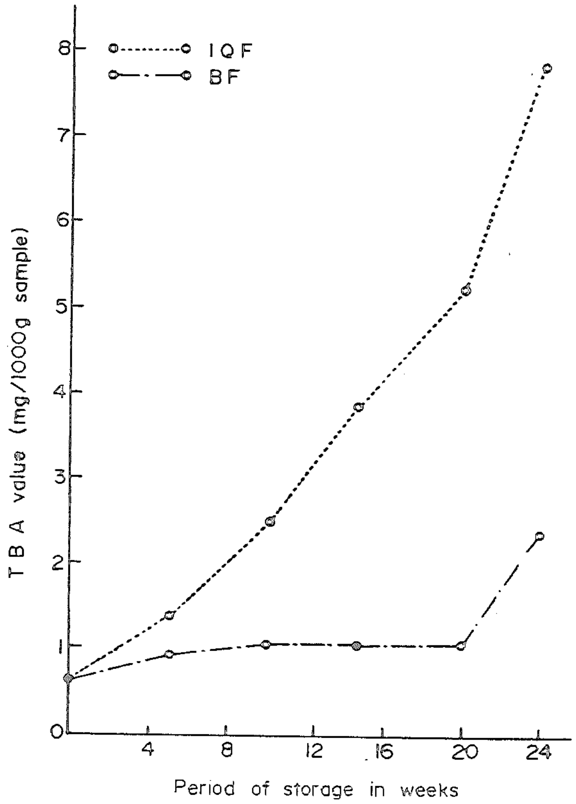

Fig. 3b. Changes in TBA value of IQF and BF mackerel (Batch II) during frozen storage

The present studies showed that mackerel can be preserved safely under frozen storage (–23°C) for a period of 23–24 weeks if quick frozen as blocks with sufficient glaze and packing.

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